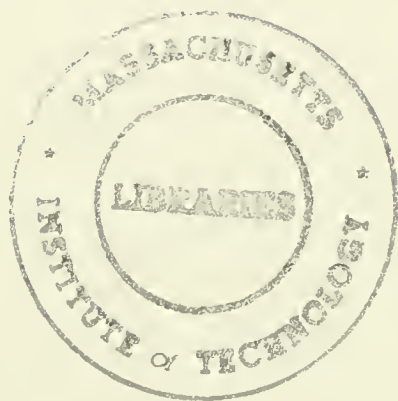


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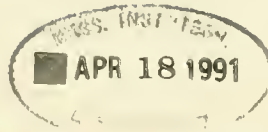




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Applicability of Expert Systems  
to Corporate Appraisal

Daisuke Okamoto

March, 1991

WP# 3264-91-BPS

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## 1. INTRODUCTION

In recent years, research in Artificial Intelligence(AI), especially Expert Systems, has come to the attention of everyone in management. The research in AI began in the mid-1950s, but has rapidly gained widespread use in the industrial world in the 1980s. The form of AI that has had the greatest use are expert systems in this movement. Expert systems are intellectual programs designed to represent and apply factual knowledge of specific areas of expertise to solve complex problems at performance levels equal to human expertise.<sup>1</sup> Many studies have been done on the application of expert systems to management. However, they only give an outline of the influences of expert systems on management. Few of them deal with expert systems directly, explain how expert systems work and what kind of conclusion expert systems produce in terms of management. Though many of them recommend the application of expert systems to management, they use a medical or engineering expert system as an example. In this paper, I wish to focus on the applicability of expert systems to management, especially corporate appraisal, which is my area of interest. For this purpose, I will develop an actual expert system for corporate appraisal, show its structure, how it works, and what level of ability it has, and explore its applicability to corporate appraisal.

## 2. MANAGEMENT, CORPORATE APPRAISAL, AND EXPERT SYSTEMS

### 2-1 WHAT ARE EXPERT SYSTEMS ?

Research in expert systems is an area of research in AI, the study of ideas that enable computers to be intelligent.<sup>2</sup> In other words, AI is the search for the actualization of human intellectual activity by computer. An inference mechanism for games and puzzles has been studied since the mid-1950s.<sup>3</sup> The goal, in those days, was to develop a simple but powerful and general purpose inference mechanism, but there were no breakthroughs. In the late-1970s, the object of study was changed from general problems to specific ones, and from the inference mechanism to the knowledge itself of the domain. This happened because AI researchers began to realize that "the problem-solving power of a program comes from the knowledge it possesses, not just from the inference mechanism it employs."<sup>4</sup> Then they began

to develop special-purpose computer programs, systems that were expert in some narrow problem area, i.e. expert systems. Since then, many studies have been done, many prototype systems have been developed, and a few of them have ever been put to practical use. Some successful examples are: XCON by Digital Equipment Corporation (configures VAX computer systems)<sup>5</sup>, DIPMETER ADVISOR by Schlumberger-Doll Research (analyzes subsurface geological structure)<sup>6</sup>, AA(Authorizer's Assistant) by American Express (complements on-line credit authorizations)<sup>7</sup>, ATREX by TOYOTA (advises on the diagnosis and repair of automobiles), BESTMIX by Sanwa Bank (picks the best portfolio), and No.5BF by Nippon Kokan (forecasts abnormal conditions on-line, and monitors and controls the furnace heat).<sup>8</sup> To sum up, expert system is a computer program which:

- infers with domain-specific knowledge,
- uses knowledge extracted from a domain expert,
- deals with highly specific, real-world problems,
- achieves the same levels of performance that a human expert can achieve.<sup>9</sup>

## 2-2 STUDIES ON EXPERT SYSTEMS IN MANAGEMENT AND ACCOUNTING

There is no study which tries to apply expert systems to corporate appraisal as this paper does, however, there are many interesting studies on expert systems in management and accounting. In this section, I will briefly review some of them.

According to Bouwman, the reason computerized diagnosis is not accepted by users is that traditional systems simply show the result, and don't show their explanatory paths. If a system shows the explanatory path along with its result, the user can double check the program's reasoning. This will also be helpful for decision making. Bouwman also analyzes the methods of operations of a group of financial diagnosticians, develops an operational computer program, and shows that his model closely mimics human decision making behavior.<sup>10</sup>

Luconi, Malone, and Scott Morton investigate the possible applications of expert systems to management. Successful examples, like XCON, operate in a fairly restricted domain where almost all of the relevant knowledge about the problem can be captured. It is

difficult to codify all the knowledge needed for less clearly bounded problems such as financial analysis, strategic planning, and project management. So efforts should be focused on designing systems that support expert users (ESS, expert support systems) rather than on replacing them.<sup>11</sup>

Thierauf states that expert systems in finance have been developed for banking, brokerage, insurance, and investment, where many inputs are necessary and many alternatives are included in the output. Yet their problem domains are too wide for expert systems and systems are very vague.<sup>12</sup>

Elmer & Borowski apply an expert system to bankruptcy analysis, and compare its ability with other models' abilities, such as a multi-variate analysis model. They find that the expert system model has the same explanatory power, and a far more robust predictive power, as compared to the other models.<sup>13</sup>

Messier & Hansen also design a bankruptcy analysis program using an expert system and get a better result than with previous models.<sup>14</sup>

There are many other studies<sup>15</sup> which illustrate the promising potential of expert systems. However, no one has developed an expert system for corporate appraisal.

## 2-3 CORPORATE APPRAISAL AND THE FEATURES OF EXPERT SYSTEMS

In this section, I will examine the features of expert systems in reference to management and corporate appraisal. Corporate appraisal can be defined as a measurement of the total potential ability of a firm for long-term survival and growth.<sup>16</sup> What kind of advantages do expert systems have for corporate appraisal? To actualize the high-level expertise for problem-solving stated in 2-1, expert systems have several features. These features are a knowledge base independent from the inference engine, a declarative knowledge representation, heuristics, and a superior user interface. These are not all independent from each other, however, let's examine one by one.

The biggest structural difference between traditional programs and expert systems is that an expert system has a knowledge base independent from its inference engine. This



feature stems from the basic precepts of expert systems which attach importance to domain knowledge itself. Here, knowledge base can be defined as domain specific knowledge which contains facts and rules for decision making. Inference engine can be defined as general problem-solving knowledge for deciding the way to apply the rules to infer new knowledge and the order in which the rules should be applied. A traditional program lumps together both knowledge base and inference engine, whereas an expert system keeps them separate. Having the knowledge base separate makes it possible for the programmer to standardize the inference engine. This means the knowledge base can be defined, certified, revised, deleted, and supplemented without affecting the inference engine.<sup>17</sup> On the other hand, for the traditional program, these changes of knowledge base affect the inference engine, and force the programmer to re-develop the whole structure.

The facility of knowledge renewal is a common advantage in all disciplines, including management. Management is a very young discipline and there aren't many universally valid systems or axioms. Knowledge renewal is often needed for such a young and developing discipline. Therefore its facility is a very important feature for the discipline. The same line of argument can be applied to corporate appraisal, as it is an area of management. Furthermore, corporate appraisal has various different goals and methodologies depending on the appraiser, such as a financial institution, an investor, a firm, a labor union, a government, a student, a research institute, and a university.<sup>18</sup> In the case of a traditional program, every appraisal needs a different program, whereas an expert system might be able to handle all of them with only slight changes to its knowledge base.

The other merit of the independent knowledge base is that domain experts can easily realize how and where their domain-specific knowledge is utilized in the system. The biggest difficulty in developing a system is how to extract and acquire the experts' knowledge. Expert systems are no exception to this fact. To make matters worse, an expert, especially in the case of management, is often not familiar with the computer program.<sup>19</sup> There have been many cases where once the system was implemented, the experts could no longer troubleshoot the system, because they could not figure out how and where their domain-

specific knowledge was being utilized in the system. If a system is an expert system, it is easier for the experts to deal with the system, because they only have to troubleshoot the knowledge base.

The second feature of expert systems is their declarative knowledge representation. There are two kinds of knowledge representation, procedural and declarative. A procedural representation defines knowledge in a sequential procedure, for example "In order to get Z, do A, do B, and do C etc.." On the other hand, a declarative representation defines knowledge in separate declarations such as rules, for example "A means B. If C then do D, etc.." Expert systems employ the declarative representation format. There is an indivisible relationship between this employment and the independence of the knowledge base, the first feature of expert systems. However, declarative knowledge alone is not enough. Procedural knowledge is necessary for a complete system. An expert system solves this by putting all procedural knowledge together with its inference engine. The knowledge base can thus be represented in a solely declarative manner.

To put it concretely, knowledge in an expert system is represented by rules such as IF.... THEN.....<sup>20</sup> As each of the IF-THEN rules is a unit or a module of knowledge, it is easier for a computer-illiterate expert such as one in management, to understand the system. This modules of knowledge format also facilitates renewal. That is, a knowledge engineer who designs and builds expert systems does not have to extract all of the domain-specific knowledge from an expert at one time. He/she can update the knowledge base with revisions and supplements. Experts usually have great difficulty in describing the domain-specific knowledge they use to develop their line of reasoning, because they use a large amount of remembered data, experiences and intuitions. This is the knowledge engineering paradox: The more competent domain experts become, the less able they are to describe the knowledge they use to solve problems!<sup>21</sup> Because, as stated previously, management has few universally valid systems or axioms, this paradox is very important for expert systems in management. A gradual development of management's knowledge base is an effective method for knowledge engineers. In addition, especially for expert systems in corporate appraisal, there are

various different goals depending on the appraiser, with each appraisal needing revisions or adjustments. Yet, if a knowledge base is in a declarative form, and has enough amount of knowledge and informations about the problem, it is possible to use the appropriate knowledge for a specific goal.<sup>22</sup> It is thus very convenient for corporate appraisal. For example, if an user wants to appraise only the profitability of a firm, the expert system will use only the rules about profitability. If the system employs a procedural knowledge representation, this kind of flexible appraisal would be impossible.

The third feature of expert systems is that the knowledge of expert systems includes many heuristics. This feature permits expert systems to display expert level problem-solving abilities. A heuristics is composed of unsystematic knowledge and/or information, which come from the expert's remembered data, experiences, and intuitions. Traditional algorithmic systems are not able to incorporate this type of knowledge, whereas expert systems introduce these heuristics into their knowledge base thereby improving their problem-solving power. For expert systems in management and corporate appraisal, the heuristics are very important because the study of management should be not only logical and systematical, but also practical.<sup>23</sup> In order to be practical, the study of management must be useful in solving real-world management problems. Heuristics in expert systems are indispensable because many managers use their own set of management heuristics in the real business world. Therefore, if heuristics are integrated into the theory of management, the growth of the discipline will be accelerated. Expert systems show great potential as the vehicle for that integration.

The fourth feature of expert systems in reference to management and corporate appraisal is their superior user interface. This concerns the manipulability of the system. First, though the knowledge of expert systems is represented in LISP, it can be easily transformed into a natural language, such as English, and therefore more easily understandable. This is because it is in IF-THEN form and also LISP is a symbol-manipulation language. Second and more important, an expert system has the ability to explain its line of reasoning.<sup>24</sup> In other words, the user can ask two questions, WHY and HOW, anytime during the consultation. WHY is a question to ask why the expert system needs the information being prompted for, and



HOW is a question to ask how the expert system has reached a conclusion. The user could not ask these questions of a traditional system which was a kind of input-output blackbox. This is the reason why the traditional systems have not been accepted by users.<sup>25</sup> WHY and HOW not only allow the user to understand the basis for the conclusion an expert system has reached, but also facilitate review and avoid the blanket acceptance or rejection.<sup>26</sup> Expert systems in management are often thought to be extensions of DSS(decision support systems). The desired answer is not a final decision but a supportive information for the decision.<sup>27</sup> Consequently, the output of a system becomes useful information only when it is in conjunction with information about the line of reasoning.

All told, every feature of expert systems points to the great potential for the applicability of expert systems to management and corporate appraisal. I will thus discuss EFSA which is an expert system for corporate appraisal in the following chapters.

### 3. EFSA

#### 3-1 THE OUTLINE OF EFSA

EFSA(Expert Financial Statement Analysis), developed by the author, is the prototype expert system for corporate appraisal. As corporate appraisal is a measurement of the total potential ability of a firm for long-term survival and growth, it takes into account various kinds of data such as top management factors, product factors, organizational factors, financial factors, and environmental factors. The nature of corporate appraisal is such that the expert systems should analyze all of these data synthetically. However, as EFSA is the first prototype, its data is restricted to the financial data of the balance sheet and the income statement. This means an analysis of publicized data. So, EFSA can be defined as the expert system which analyzes and explains financial statements at a performance level equal to human expertise.

The domain-specific knowledge of EFSA has been developed by the author with the total cooperation of Dr.Kiyoshi Okamoto, Professor of Accounting at Hitotsubashi University, Tokyo. First, the knowledge about financial ratios and its usages were extracted by the author from

the books of Dr.K.Okamoto<sup>28</sup> with his permission. Next, the combinatorial appraisals<sup>29</sup> were developed by the author using his own interpretation. Then they were checked and revised by Dr.K.Okamoto. In knowledge engineering jargon, Dr.K.Okamoto was a domain expert, and the author was the knowledge engineer and domain expert.

PC-PLUS, an expert system building tool for AT-class personal computers by Texas Instruments Inc., has been used to develop EFSA. A PC-6310 AT&A personal computer (East Campus Computer Facility, Sloan School of Management, MIT) is the type of computer used.

### 3-2 THE FEATURES OF EFSA

The tasks EFSA performs are broadly divided into three categories: presentation of goals, selection and explanation of financial ratios, and calculation and interpretation of financial ratios. First, EFSA presents the appropriate goals for corporate appraisal and prompts the user to select. EFSA uses four goals for the measurement of the total potential ability of a firm for long-term survival and growth, i.e. profitability, productivity, stability, and growth. Each goal constitutes the frame.<sup>30</sup> Though all four goals have to be analyzed for the overall corporate appraisal, individual analysis is possible depending on the needs of the user. During the consultation, the meaning of each goal is going to be indicated, and the user can decide whether each goal is to be analyzed or not.

Secondly, EFSA shows the financial ratios to be analyzed for each selected goal and explains their meanings. Actually, there are a large number of financial ratios in a textbook of financial analysis. Take, for instance, the profit rate. The numerator of the ratio can be any kind of profit, such as gross profit, operating profit, ordinary profit, net profit before tax, and net profit after tax. The denominator of the ratio can be any kind of capital, such as total capital, equity capital, capital stock, and operating capital. Furthermore, sales can also be used as the denominator of the ratio. Twenty-five financial ratios can be produced mathematically using the variables just listed. There are several hundreds of financial ratios altogether, however, an expert would not use all of them. In fact, although some of them can be produced mathematically, they might not have meaning in a



managerial or accounting sense. There should be a causal relationship between the numerator of a financial ratio and its denominator.<sup>31</sup> In addition, even if a financial ratio has logical meaning, it might have a high correlation with other ratios. EFSA selects and recommends the appropriate financial ratios to be analyzed for selected goal, and if necessary, explains their meanings.

Finally, EFSA calculates and interprets the selected financial ratios. The most difficult task in the financial statement analysis is the interpretation of the calculated figures. Even a novice, or a simple traditional system can calculate a financial ratio, given a formula. What is difficult is the interpretation of the result. This difficulty stems from the fact that any single ratio does not have big explanatory power. In other words, the ratio's transitional changes, as well as its mutual relationships with other ratios should be considered together. EFSA's many rules help it to make these judgements. Using its combinatorial appraisal, it interprets the results at performance levels equal to human expertise.

### 3-3 EFSA'S METHOD OF REASONING

There are two important methods by which rules can be used in an IF-THEN type rule-base system; one is called forward chaining and the other backward chaining.<sup>32</sup> With forward chaining, the IF-part of each rule is checked by using individual facts and data. The first or topmost rule that matches is executed or fired, and the data base is revised. Then, the next rule to be fired is searched until a certain conclusion is found. This is the basic inference method of a rule-based system. It is easy to understand, because the search for new information seems to be proceeding in the direction of IF → THEN. However, even when the user wants to prove only one specific goal to be true, many rules must be searched and much input must be prompted that have nothing to do with the goal. This is the disadvantage of this method. On the other hand, with backward chaining, a hypothesis is set as a candidate for the goal(conclusion). There is a search for the rule whose THEN-part is necessary to attain the hypothesis. The IF-part of the rule is set as a subgoal. Then there

is a search for the rule whose THEN-part is necessary to attain the subgoal. The same cycle is repeated until the goal is proven true. The system starts with what it wants to prove, and only executes the rules that are relevant to the establishment of that proof. Thus, the user does not have to input unrelated data. However this method also has certain disadvantages. If there are many candidates to be proven, it would take a lot time to check all of them. Therefore these two methods have both advantages and disadvantages. The user should select a method based on the purpose of his/her inquiry. If the purpose is to discover all that can be deduced from a given set of facts, then forward chaining should be chosen. If the purpose is to verify or deny one particular conclusion, then backward chaining should be chosen.<sup>33</sup>

EFSA basically works with backward chaining.<sup>34</sup> As mentioned earlier, there are a lot of information which can be analyzed by a set of given financial data. If forward chaining is chosen, all information about the goal that can be drawn from the data will be analyzed, and much work may be wasted in developing unrelated conclusions. The user may have to answer a lot of questions prompted for by the system. Depending on a goal the user wants to reach, a completely irrelevant information and/or similar mutually correlated information might be led to a conclusion that might be redundant. Needless to say, an expert knows how and which data should be analyzed for corporate appraisal. It is enough that a certain information is analyzed and verified. Consequently, backward chaining is the appropriate inference method for financial statement analysis. In addition, Winston states that the shape of the state space determines which method is better(Figure 1). As mentioned later, the shape of the state space of EFSA is only comprised of fan-out situations. These facts support EFSA's employment of backward chaining.<sup>35</sup>

### 3-4 RULES OF EFSA

EFSA holds 353 IF-THEN rules. These are the source of its expert level problem-solving power. In this section, the essential parts of the rules will be explained.<sup>36</sup>

PROFITABILITY-FRAME performs the profitability analysis. Several profit rates and

turnovers are analyzed. RULE058(Figure 2) controls the entire analysis of the frame. When the user requires a profitability analysis, RULE058 is searched first. This is done because PROFITABILITY-EVA, which is included in the THEN-part of the rule, is the goal of the frame. Then each IF-part becomes a subgoal. Namely, rules which include a part of RULE058, such as RETURN-ON-TOTAL-ASSETS-EVA or RETURN-ON-EQUITY-EVA or .... or TRADE-RECEIVABLES-TURNOVER-EVA in their THEN-part are going to be searched for one by one.

When the return on total assets(ROTA) is calculated, only a routine appraisal is executed. In the routine appraisal, ROTA of the firm is compared with the industry average as a criterion. This produces the three-level assessment of GOOD, FAIR, or POOR. During the consultation, the information will be shown on the screen, such as ROTA of the firm, the industry average of ROTA, the difference between the two, and so on.<sup>37</sup> ROTA is classified as GOOD when it is greater than  $(100 + x)\%$  of the criterion, POOR when less than or equal to  $(100 + x)\%$ , FAIR when otherwise.<sup>38</sup> Besides, the default value of  $x$  is 10.0, however, it can be changed at the user's discretion.

When the return on equity(ROE) is calculated, the routine appraisal produces the two-level assessment of 2(good; greater than or equal to the criterion) or 1(bad; less than the criterion). Then, the combinatorial appraisal is carried out in relation to ROTA and the net worth ratio(NWR). This combinatorial appraisal is the distinctive feature of EFSA. It is performed by RULE113-RULE120. An example of those rules is shown in Figure 2, and of the state space of those rules in Figure 3. The result given by each routine appraisal of ROE, ROTA, and NWR, determines which rule is to be selected from the state space. The comment which is included in the THEN-part of the selected rule becomes the conclusion of ROE analysis.

With every conclusion, CF(certainty factor) is calculated. Generally, the rules in an expert system aren't always either true or false; sometimes there is a degree of uncertainty about the validity of a rule.<sup>39</sup> CF indicates the degree of validity. Though the information about the difference between the figure of the measure and its criterion is on the screen, EFSA uses the two-level assessment of 2(good) or 1(bad) in its combinatorial appraisal.



Hence CF is used to compensate for the simplicity of assessment. CF is calculated as follows.

Suppose the following rule is fired.<sup>40</sup>

IF  $\{X_1 \geq N(X_1)\}$  AND  $\{X_2 \geq N(X_2)\}$  AND  $\{X_3 < N(X_3)\}$  AND ..... AND  $\{X_n \geq N(X_n)\}$   
THEN P

where N indicates the criterion of each variable.

Then CF of the conclusion P is

$$1 - \sum_{i=1}^n \beta_i$$

where  $A_1$  is the difference between  $X_1$  and its criterion [ $A_1 = |X_1 - N(X_1)| / N(X_1)$ ];

$\alpha$  is a constant;

$\beta_1$  is the certainty of the fact  $\{X_1 \geq N(X_1)\}$  or  $\{X_1 < N(X_1)\}$

[ $\beta_1 = 100$  for  $A_1 \geq \alpha$ ]

[ $\beta_1 = 90$  or  $80$  or ..... or  $10$  or  $0$

on condition that  $\{1 + \alpha \beta_1 / 100 > A_1 \geq \alpha \beta_1 / 100\}$  for  $A_1 < \alpha$ ]

CF of EFSA is shown from 0-100. A low CF means that the degree of validity about the fact included in the IF-part of the rule is low, and warns that the user should check the validity of the rule in detail. Besides, though the default value of  $\alpha$  is 10.0, it can be changed at the user's discretion.

When,  $n = 3$ ,  $X_1 = 12.5$ ,  $N(X_1) = 10.0$ ,  $X_2 = 5.8$ ,  $N(X_2) = 5.6$ ,  $X_3 = 69.4$ ,  $N(X_3) = 76.3$ , and supposing the following rule is fired:

IF  $\{X_1 \geq N(X_1)\}$  AND  $\{X_2 \geq N(X_2)\}$  AND  $\{X_3 < N(X_3)\}$

THEN P

$\beta_1$  is calculated to be 100;  $\beta_2$ , 30;  $\beta_3$ , 90; CF of P, 73.

This (73 CF) means that  $X_1$  is enough greater than its criterion and  $X_3$  is almost sufficiently less than its criterion. However,  $X_2$  is almost same as its criterion, though greater.

When the return on operating assets(ROOA) is calculated, the combinatorial appraisal is carried out using the results of the routine appraisals of ROOA, ROTA, and the relative size of the two. This appraisal aims to focus on the firm's performance in the main line of business. It is performed by RULE066-RULE075. An example of those rules is shown in Figure 2, and of the state space in Figure 4. In the same way, the appraisals of the parts of ROOA, the operating income ratio(OIR) and the operating assets turnover(OAT), are performed by RULE076-RULE083. The appraisals of the part of OIR, the cost of sales ratio(COSR) and the selling, general and administrative expenses ratio(SGAAER), are performed by RULE084-RULE091. The appraisals of the important components of OAT, the raw materials turnover(RMT), the work in process turnover(WIPT), the goods turnover(GT), and the trade receivables turnover(TRT), are performed by RULE092-RULE111. Examples of those rules are shown in Figure 2, and of the state spaces in Figure 5-10. In short, the routine appraisals are carried out by comparing each important measure with its respective criterion. The state spaces are developed in

conjunction with relative measures. Then a conclusion is chosen from the candidates. As stated earlier, backward chaining has the disadvantage of slow execution if there are many candidates, however, making the state space for each subgoal separately helps keep the execution speed from lowering.

PRODUCTIVITY-FRAME performs the productivity analysis with almost the same process as PROFITABILITY-FRAME. First, the value-added labor productivity(VALP) is selected as the overall productivity measure, then it is broken down into the labor equipment ratio(LER) and the equipment productivity(EP). Next, EP is broken down into the property, plant and equipment turnover(PPAET) and the value-added ratio(VAR). Furthermore, the labor's share(LSS) and the per capita personnel expenses(PCPE) are analyzed in relation to VALP. RULE216 controls the entire analysis of the frame(Figure 11). PRODUCTIVITY-EVA, which is included in the THEN-part of the rule, is the goal of the frame. Each IF-part becomes a subgoal. The rules whose THEN-parts include the subgoal are going to be searched one by one. The analyses of LER and EP are performed by RULE224-231; the analyses of PPAET and VAR by RULE232-RULE239; the analyses of LSS and PCPE by RULE240-RULE247. Examples of those rules are shown in Figure 11, and of the state space in Figure 12-14.

STABILITY-FRAME performs the stability analysis. The goal of this frame is STABILITY-EVA, which is included in RULE001(Figure 15). The IF-parts of the rule control short and long stability analyses. For short stability analysis, four measures(the current ratio:CR, the quick ratio:QR, the cash ratio:CAR, and the net interest burden:NIB) are used in each routine appraisal. They are also used in the combinatorial appraisal, which is performed by RULE026-RULE041. An example of those rules is shown in Figure 15, and of the state space in Figure 16. For long stability analysis, three measures(the liability ratio:LR, the fixed assets ratio:FAR, and the long-term fund ratio:LTFR) are used. The combinatorial appraisal is performed by RULE042-RULE049. An example of those rules is shown in Figure 15, and of the state space in Figure 17.

GROWTH-FRAME performs the growth analysis using almost same process as STABILITY-FRAME. Three measures(the sales growth rate:SGR, the two years sales growth rate:TYSGR, and the

ordinary income growth rate:OIGR) are used. The combinatorial appraisal is performed by RULE194-RULE204. An example of those rules is shown in Figure 19, and of the state space in Figure 18.

Taken together, EFSA presents four goals(profitability, productivity, stability, and growth) to the user for selection, carries out the routine appraisal for each appropriate measure using the criterion, carries out the combinatorial appraisal which is the distinctive feature of EFSA, and produces a conclusion. The number of candidates for each combinatorial appraisal are shown in Table 1. For instance, three measures(ROTA, ROE, and NWR) are used for the combinatorial appraisal of ROE. There are eight candidates for the conclusion. The number of candidates is 54 for the profitability analysis, and 110 for all four analyses. As a result, there are a possible 671,088,640 kinds of corporate appraisal which can be produced logically using those candidates.<sup>41</sup> Generally, there are two types of conclusions an expert system can make, i.e. an analysis oriented conclusion and a synthesis oriented conclusion.<sup>42</sup> In the former type, the given data is analyzed and compared with a prepared set of hypotheses. The hypothesis which best explains the given data is selected as the conclusion. In the latter type, the best or the most feasible conclusion is produced using the given constraints or given data. The conclusion of EFSA is selected from the prepared set of hypotheses. It is an analysis oriented conclusion. Yet there are practically an infinite numbers of candidates,<sup>43</sup> and it is no exaggeration to say that EFSA produces a synthesis oriented conclusion.

#### 4.ACTUAL CONSULTATION BY EFSA

In this chapter, I will show how EFSA works with financial data in an actual consultation. ➤ indicates an input by the user, and ☆☆☆ indicates an output by EFSA.



#### 4-1 COMMON DATA INPUT (ANALYSIS-FRAME)

##### EXPERT FINANCIAL STATEMENT ANALYSIS (EFSA) :: (ver.1.33)

DAISUKE OKAMOTO : Knowledge Engineer & Domain Expert  
Associate Professor of Management,  
Keio University  
Visiting Scholar, Sloan School of Management,  
Massachusetts Institute of Technology

KIYOSHI OKAMOTO : Domain Expert  
Professor of Accounting,  
Hitotsubashi University

Special thanks to Ms. Patricia Robinson, MIT Sloan School

\*\* End - RETURN/ENTER to continue

This is the front page of EFSA. At start of the program, EFSA creates the root frame (ANALYSIS-FRAME), and prompts the user to input all of the common data which is necessary for every analysis.

> (RETURN)

☆☆☆ What is the name of the firm that you are considering for ANALYSIS,  
and the name of its competitor(if any)?

> OK COMPANY

The data used in this consultation is data about the hypothetical company, the OK COMPANY, which is assumed to be an average Japanese listed company with 6,000 employees, 16 billion yen (\$123 million) of capital stock, 150 billion yen (\$1.15 billion) of total assets, and 200 billion yen (\$1.54 billion) of sales.

☆☆☆ EFSA has two analysis modes. PROBLEM means that EFSA will analyze only problems. In this mode, EFSA will not find the causes of good conditions, but only the causes of bad conditions. FULL means that EFSA will do full consultations. In this mode, EFSA will find the causes of both good and bad conditions. Please select one of them. [PROBLEM FULL]

> FULL

☆☆☆ EFSA has a time series mode. If you select YES for this mode, EFSA will analyze the changes in each measure over the past three years. Would you like to do it? [YES NO]

> YES

☆☆☆ EFSA has a competitor mode. If you select YES for this mode, EFSA will make a comparison between your firm and your competitor. Would you like to do it?

[YES NO]

> NO

☆☆☆ Cost of sales? (the latest year)

> 1352<sup>44</sup>

☆☆☆ Cost of sales? (the year before last)

> 1068

☆☆☆ Cost of sales? (two years before last)

> 1024

☆☆☆ Selling, general and administrative expenses? (the latest year)

> 376

Inputs of prompted financial data follow after these inputs. Here, only the minimum required data will be prompted. Data such as sales or total assets, which can be worked out by using other data, will not be prompted. Table 2 shows the list of the input data.

#### 4-2 PROFITABILITY ANALYSIS (PROFITABILITY-FRAME)

☆☆☆ The analysis of profitability evaluates the earning power of the firm. The core notion here is the return on investment(ROI) which gives an indication of the firm's efficiency in using its capital. The important thing is to choose the appropriate profit(numerator) to combine with the appropriate capital or assets(denominator), because there should be a causal relationship between the numerator and the denominator. I will recommend some useful and proper ratios, and analyze them. Would you care to analyze the profitability of the firm?

[YES NO]

> YES<sup>45</sup>

(Data input for the profitability analysis. See Table 3.)

☆☆☆ I will calculate the return on total assets. Would you like to have the explanation for the ratio? [YES NO]

> YES<sup>46</sup>

☆☆☆ The formula for the return on total assets is (Ordinary Income)/(Total Assets)\*100. This ratio is designed to indicate how efficiently the total assets are being utilized by a firm, i.e. the total earning power of the firm, using the industry average as a criterion. Strictly speaking, since there should be a causal relationship between the numerator and the denominator, the numerator should be (Ordinary Income)+(financing charges), because the denominator includes not only the equity capital but also the borrowed capital. Usually, however, only ordinary income is used for the numerator. Therefore I will use that to allow for interfirm comparisons.  
When you need this explanation hereafter, press F2, select HOW, and choose EXPLAIN-(name of the ratio).

As shown in the last line, this explanation is always available during the consultation.<sup>47</sup>

☆☆☆ How much is the latest average rate of return on total assets in the industry?

> 10.50

☆☆☆ The return on total assets of the firm is ABOVE the average of the industry:  
12.36.

The difference from the average(10.50) is 17.71%.

The returns on total assets for the last three years are 11.74, 13.62, and 12.36. The changes are 16.01% and -9.25%.



The above explanation of the measure, the comparison to the criterion, and the time series analysis(when requested) comprise the routine appraisal which will be carried out for all measures. The difference from the criterion is calculated as  $|ROTA - \text{Criterion}| / \text{Criterion} * 100$ . In the case of the firm,  $|12.36 - 10.50| / 10.50 * 100 = 17.71\%$ . The calculations for the time series analysis are done in the same way. When requested, a comparative analysis of the competitor will be carried out after these appraisals.

(Prompt for the explanation of ROE)

> YES

☆☆☆ The formula for the return on equity is  $(\text{Ordinary Income})/(\text{Equity Capital}) * 100$ . This ratio is designed to indicate how efficiently the equity capital is being utilized by the firm, using the industry average as a criterion. The relationship between ROTA and ROE is as follows;  $(ROTA) = (ROE) * (1.0 - \text{leverage factor})$ , where the leverage factor is  $(\text{Borrowed Capital})/(\text{Total Assets})$ . It can be said that when ROTA is constant, the higher the leverage factor, the higher ROE. This is the financial leverage effect.

(Prompt for the criterion of ROE)

> 35.80

☆☆☆ The return on equity of the firm is ABOVE the average of the industry: 47.37. The difference from the average(35.80) is 32.32%.

The returns on equity for the last three years are 42.86, 48.24, and 47.37. The changes are 12.55% and -1.80%.

Both the total profitability and the equity profitability are good, but the latter is the result of large borrowed capital, i.e. favorable financial leverage effect. Once the firm's total profitability goes down because of a depression or for other reasons, the equity profitability might go down even more, due to the inverse effect of financial leverage. (100 CF)

When you want to read this evaluation hereafter, press F2, select How, and choose EVALUATE-(name of the attribute).

Here, the combinatorial appraisal, which is the distinctive feature of EFSA, has been carried out after the routine appraisal. As shown in the last line, the conclusion of the combinatorial appraisal is always available during the consultation.<sup>48</sup>

(Prompt for the explanation of ROOA)

> YES

☆☆☆ The formula for the return on operating assets is  $(\text{Operating Income})/(\text{Operating Assets}) * 100$ , where  $\text{Operating Assets} = \text{Total Assets} - (\text{Construction in progress, Investments, Deferred charges})$ . The denominator(Operating Assets) refers to the assets which were used directly for production and sales. The numerator(Operating Income) refers to the income which was generated directly from production and sales. Therefore, this ratio is intended to focus on the firm's performance in the main line of business using the industry average as a criterion.

(Prompt for the criterion of ROOA)

> 12.90

☆☆☆ The return on operating assets of the firm is ABOVE the average of the industry: 16.02.

The difference from the average(12.90) is 24.19%.

The returns on operating assets for the last three years are 13.60, 15.72, and 16.02. The changes are 15.59% and 1.19%.

Both ROOA and ROTA are above average levels. Furthermore, ROOA > ROTA. This means that the firm's performance in the main line of business is very good. Its performance in the other concomitant activity, such as financial management, is probably good, or at least not too bad. Even if it is below par, this isn't critical because of the favorable condition of the main line of business. (100 CF)

The changes of ROTA from the first period to the third are +16.01% & -9.25%. The changes of ROOA are +15.59% & +1.19%. Though EFSA does not point it out, these facts mean that the cause of the decline of ROTA in the third period should be attributed to the other concomitant activity rather than to the main line of business. There might be an increase in non-operating expenses, such as the interest and discount paid, so a check on the corresponding items will be needed.

(Prompt for the explanation of OIR & OAT)

>> YES

☆☆☆ The formulas for the operating income ratio and the operating assets turnover are  $(OIR) = (\text{Operating Income}) / (\text{Sales}) * 100$  and  $(OAT) = (\text{Sales}) / (\text{Operating Assets})$ . These ratios are components of ROOA, which can be broken down as follows:  $(ROOA) = (OIR) * (OAT)$ . OIR indicates what level of profits were included in a unit of sales, i.e. earnings per sales, and OAT indicates what level of sales could be generated by a unit of operating assets, i.e. the degree of utilization of operating assets, using the industry averages as criteria. Strictly speaking, when turnover is calculated, the appropriate cost should be used in the numerator instead of sales. In the case of OAT, the total cost of sales (Cost of Sales + Selling, General and Administrative Expenses) should be used. However, since sales is what is usually used, I will use that to allow for interfirm comparisons.

(Prompt for the criterion of OIR. The criterion of OAT is worked out by EFSA)

>> 10.10

☆☆☆ The operating income ratio of the firm is ABOVE the average of the industry: 11.84.

The difference from the average(10.10) is 17.23%.

The operating income ratios for the last three years are 8.86, 11.99, and 11.84. The changes are 35.33% and -1.25%.

The operating assets turnover of the firm is ABOVE the average of the industry: 1.35.

The difference from the average(1.28) is 5.47%.

The operating assets turnovers for the last three years are 1.54, 1.31, and 1.35. The changes are -14.94% and 3.05%.

According to these facts, it can be said that the reason of the high return on operating assets is found in the high operating income ratio and also the high operating assets turnover. (83 CF)

The (83 CF) indicates that the main reason for high ROOA should be attributed to high OIR (+17.23% above its criterion), rather than to OAT which is only +5.47% above its

criterion.

(Prompt for the explanation of COSR & SGAAER)

> YES

☆☆☆ The formulas for the cost of sales ratio and the selling, general and administrative expenses ratio are  $(\text{COSR}) = (\text{Cost of Sales}) / (\text{Sales}) * 100$ , and  $(\text{SGAAER}) = (\text{Selling, General and Administrative Expenses}) / (\text{Sales}) * 100$ . These ratios are components of OIR, which can be broken down as follows:  $(\text{OIR}) = 100 - (\text{COSR}) - (\text{SGAAER})$ . In this way, you can analyze the cause of high (or low) figure of OIR, using the industry averages as a criteria.

(Prompt for the criterion of COSR. The criterion of SGAAER is worked out by EFSA.)

> 71.40

☆☆☆ The cost of sales ratio of the firm is BELOW the average of the industry: 68.98.

The difference from the average(71.40) is -3.39%.

The cost of sales ratios for the last three years are 73.14, 68.11, and 68.98.

The changes are -6.88% and 1.28%.

The selling, general and administrative expenses ratio of the firm is ABOVE the average of the industry: 19.18.

The difference from the average(18.50) is 3.68%.

The selling, general and administrative expenses ratios for the last three years are 18.00, 19.90, and 19.18. The changes are 10.56% and -3.62%.

According to these facts, it can be said that the reason of high OIR is found in low COSR. The firm can raise its OIR by improving the management of SGAAE.

Check on the detailed statement of manufacturing cost is recommended concerning low COSR. (53 CF)

The (53 CF) indicates that high OIR is due to low COSR, however, it is only -3.39% below the criterion. Furthermore, although SGAAER is higher than its criterion, it is only +3.68% above. Yet, the time series analysis indicates that, in general, COSRs show a downward trend, and SGAAERs show an upward trend. Therefore, the conclusion of EFSA must be right.

(Prompt for the explanation of RMT, WIPT, & GT)

> YES

☆☆☆ The formulas for three inventory turnovers(raw materials turnover, work in process turnover, and goods turnover) are as follows;  $(\text{RMT}) = (\text{Sales}) / (\text{Raw Materials})$ ,  $(\text{WIPT}) = (\text{Sales}) / (\text{Work in Process})$ , and  $(\text{GT}) = (\text{Sales}) / (\text{Goods})$ . The basic concept of these turnovers is the belief that the smaller the each of the inventory levels needed to support a given volume of sales(i.e. the higher the turnover), the more efficient the management of inventories, using the industry averages as a criteria.

(Prompt for the criteria)

> 51.10, 36.70, 46.00

☆☆☆ The raw materials turnover of the firm is ABOVE the average of the industry: 54.44.

The difference from the average(51.10) is 6.54%.

The raw materials turnovers for the last three years are 43.75, 39.20, and 54.44. The changes are -10.40% and 38.88%.

One of the reasons of high OAT should be attributed to high RMT. This means that the firm could attain an efficient raw materials management. (55 CF)



The (55 CF) indicates the following points with regard to the conclusion. First of all, OAT is only +5.47% above the criterion. Also RMT is only +6.54% above the criterion. Yet, RMTs show an upward trend and thus the conclusion of EFSA is supportable.

☆☆☆ The work in process turnover of the firm is BELOW the average of the industry: 35.00.  
The difference from the average(36.70) is -4.63%.  
The work in process turnovers for the last three years are 43.75, 30.15, and 35.00. The changes are -31.09% and 16.09%.  
The management of work in process was poor and couldn't contribute to high OAT. See the analysis of productivity. (45 CF)

☆☆☆ The goods turnover of the firm is BELOW the average of the industry: 32.67.  
The difference from the average(46.00) is -28.98%.  
The goods turnovers for the last three years are 58.33, 65.33, and 32.67. The changes are 12.00% and -49.99%.  
The low goods turnover means that goods had been held for a long time and that large inventories might be kept. The goods had not been sold well and/or had been overproduced. So the turnover could not contribute to high OAT. See the analysis of productivity. (75 CF)

The reason that both CFs are below 100 is same as that of RMT. However, in the case of GT, it is far below the criterion (-28.98%), and shows a sharp decline in the third period. Thus, as EFSA points out, the possibility of inactive sales and/or overproduction should be considered.

(Prompt for the explanation of TRT, TRHP, & TPHP)

>> YES

☆☆☆ The trade receivables turnover is a component of the operating assets turnover and the formula is  $(\text{Sales}) / ((\text{Accounts Receivable}) + (\text{Notes Receivable}))$ . The concept of this turnover is same as inventory turnovers, using the industry average as a criterion. The trade receivables holding periods is calculated as  $(1.0) / (\text{TRT}) * 365$ , and the trade payables holding periods is calculated as  $((\text{Accounts Payable}) + (\text{Notes Payable})) / (\text{Sales}) * 365$ . These two holding periods indicate how much trade receivables and trade payables the firm holds in terms of daily volume of sales, therefore, TRHP should be greater than TPHP.

(Prompt for the criterion of TRT)

>> 8.20

☆☆☆ The trade receivables turnover of the firm is BELOW the average of the industry: 4.78.  
The difference from the average(8.20) is -41.71%.  
The trade receivables turnovers for the last three years are 5.93, 5.98, and 4.78. The changes are 0.84% and -20.07%.  
The trade receivables holding periods is GREATER than the trade payables holding periods; 76.35 > 59.03.  
Though TRHP is greater than TPHP, low TRT means that collecting trade receivables has taken longer time than average. Trade receivables management was not good and could not contribute to high OAT. (75 CF)

The time series analysis shows a sharp decline in TRT. Though EFSA does not point it

out, it means that there is the possibility of inactive sales, and a check is necessary.

☆☆☆ The evaluation of the profitability has been completed. Profitability is GOOD.

For the present, EFSA has finished the profitability analysis with the appraisal of GOOD. This comes from the three-level assessment of ROTA which is the overall profitability measure in EFSA.<sup>49</sup> Though it is rated as GOOD, the user should be concerned about the pending problems which have been found during the consultation.

#### 4-3 PRODUCTIVITY ANALYSIS (PRODUCTIVITY-FRAME)

☆☆☆ The analysis of productivity evaluates how much value the firm has generated. The core notion here is value-added, which is the net value generated within the firm; Value-added = Ordinary income (or Operating income) + Personnel expenses + Financial expenses + Rent + Taxes and public charges (+ Depreciation expenses). (Depreciation expenses are included for interfirm comparisons.) Using this measure, I will analyze the generation and the distribution of value-added. Would you care to analyze the productivity of the firm? [YES NO]

> YES

(Data input for the productivity analysis. See Table 4.)

(Prompt for the explanation of VALP)

> YES

☆☆☆ Value-added is the net value generated within the firm. This measure has a strong correlation with sales and profitability, however, each measure has different meaning. If a firm buys a lot of parts from outside or uses many outside products, it doesn't generate a large amount of value-added even if the firm has a large amount of sales. If a firm cuts down its personnel expenses, its profitability increases even if its productivity doesn't change. In latter case, the morale of employees will be lowered and the profitability of the firm might even go down in near future. On the contrary, if the amount of value-added is high, it means high sales and also high profitability. Therefore a large amount of value-added assures that the firm can attain high profitability sustainably. This is the analysis of the generation of value-added. Usually the value-added labor productivity is used for this analysis to allow for interfirm comparisons. The formula is (Value-added)/(Number of employees). This is the most typical measure as a labor productivity measure.

(Prompt for the criterion of VALP)

> 0.1056

☆☆☆ The value-added labor productivity of the firm is ABOVE the average of the industry: 0.1100.

The difference from the average(0.1056) is 4.17%.

The value-added labor productivities for the last three years are 0.0822, 0.0988, and 0.1100. The changes are 20.19% and 11.34%.

(Prompt for the explanation of LER & EP)

> YES

☆☆☆ The formulas for the labor equipment ratio and the equipment productivity are (LER)=((Property, plant and equipment)-(Construction in progress))/(Number of employees), and (EP)=(Value-added)/((Property, plant and equipment)-(Construction in progress))\*100. These ratios are components of VALP, which can be broken down as follows: (VALP)=(LER)\*(EP)/100. This means the

productivity(VALP) depends on the quantity of per capita equipment(LER) and the quality of production by the equipment(EP).  
(Prompt for the criterion of LER. The criterion of EP is worked out by EFSA.)

> 0.1094

☆☆☆ The labor equipment ratio of the firm is BELOW the average of the industry: 0.1000.

The difference from the average(0.1094) is -8.59%.

The labor equipment ratios for the last three years are 0.0547, 0.0889, and 0.1000. The changes are 62.52% and 12.49%.

The equipment productivity of the firm is ABOVE the average of the industry: 110.03

The difference from the average(96.53) is 13.99%.

The equipment productivities for the last three years are 150.32, 111.17, and 110.03. The changes are -26.04% and -1.03%.

According to these facts, it can be said that the reason of the high productivity(VALP) is found in the high quality of production by the equipment (EP). The firm can raise its productivity further by improving the quantity of per capita equipment(LER). Increasing amount of investment on plant and equipment is recommended. If LER has been increased, there is a possibility that the firm has made an investment. Check the machinery and equipment account(in the property, plant and equipment account of B/S) and the depreciation expenses account(in the expenses account of the detailed statement of manufacturing cost). (73 CF)

With regard to the conclusion that high VALP is found in high EP and its (73 CF), the user should note that VALP is only +4.17% above its criterion. He/she should also note that EP is high (+13.99%), but LER is not very low (-8.59%). Furthermore, EPs show a downward trend, and LERs show an upward trend. Therefore, the reason for the improvement of VALP should be attributed to the improvement of LER and there is a possibility that the firm has made a capital investment as EFSA points out. There are, however, several inconsistencies that suggest the investment has not been successful. The user should keep these issues in mind.

(Prompt for the explanation of PPAET & VAR)

> YES

☆☆☆ The formulas for the property, plant and equipment turnover and the value-added ratio are  $(PPAET) = (\text{Sales}) / ((\text{Property, plant and equipment}) - (\text{Construction in progress}))$ , and  $(VAR) = (\text{Value added}) / (\text{Sales}) * 100$ . These ratios are components of EP, which can be broken down as follows:  $(EP) = (PPAET) * (VAR)$ . This means the quality of production by the equipment(EP) depends on the degree of utilization of the equipment(PPAET) and the quality of the equipment itself(VAR).

(Prompt for the criterion of PPAET. The criterion of VAR is worked out by EFSA.)

> 4.28

☆☆☆ The property, plant and equipment turnover of the firm is BELOW the average of the industry: 3.22.

The difference from the average(4.28) is -24.77%.

The property, plant and equipment turnovers for the last three years are 4.43,



2.97, and 3.22. The changes are -32.96% and 8.42%.  
The value-added ratio of the firm is ABOVE the average of the industry: 34.13.  
The difference from the average(22.55) is 51.35%.  
The value-added ratios for the last three years are 33.93, 37.44, and 34.13.  
The changes are 10.34% and -8.84%.  
According to these facts, it can be said that the reason of the high quality of the production by the equipment(EP) is found in the high quality of the equipment itself(VAR). The firm can raise its EP further by improving the degree of utilization of the equipment(PPAET). Check on an idle and unused equipment or unsuitable equipment is recommended to avoid producing products which do not meet user needs and not sell well. (100 CF)

EFSA concludes that the reason for high EP should be attributed to high VAR. The time series analysis indicates that PPAETs are showing a downward trend. This is the cause of the decline of EP. In summary, the firm made a capital investment, and tried to improve its productivity(VALP) by increasing the quantity of per capita equipment(LER). However, it didn't work well and lowered the quality of production by the equipment(EP). Detailed analysis shows that the cause of low EP is found in the low degree of utilization of the equipment(PPAET). This means that the firm invested in equipment, but the equipment is not being fully utilized, and the firm's products have not sold well despite the positive investment. Though the quality of the equipment itself(VAR) has maintained a high standard, and the firm is making high value-added products, they are not meeting user needs. Incidentally, these conclusions explain the inactive sales and/or the overproduction which were inferred by the decline of GT and TRT.

(Prompt for the explanation of LSS & PCPE)

> YES

☆☆☆ Value-added consists of the ordinary income(or the operating income), the personnel expenses, the financial expenses, the rent, and taxes & public charges. The ordinary income, the financial expenses, and the rent mean the distributions to capital; the personnel expenses, to labor; taxes & public charges, to public. A firm has to consider the shares for labor and capital, because the share for public are given. This is the analysis of distribution of value-added. For this purpose, the labor's share and the per capita personnel expenses are calculated as  $(LSS) = (\text{Personnel expenses}) / (\text{Value-added}) * 100$ , and  $(PCPE) = (\text{Personnel expenses}) / (\text{Number of employees})$ . LSS and VALP are components of PCPE, which can be broken down as follows:  $(PCPE) = (LSS) / 100 * (VALP)$ . This means an increase of the personnel expenses can be attained by an increase of the productivity, even though its labor's share is the same level.

(Prompt for the criterion of LSS. The criterion of PCPE is worked out by EFSA.)

> 55.26, 0.0584

☆☆☆ The labor's share of the firm is BELOW the average of the industry: 50.82.  
The difference from the average(55.26) is -8.03%.  
The labor's shares for the last three years are 55.16, 48.04, and 50.82. The

changes are -12.91% and 5.79%.

The per capita personnel expenses of the firm is BELOW the average of the industry: 0.0559.

The difference from the average(0.0584) is -4.28%.

The per capita personnel expenses for the last three years are 0.0453, 0.0475, and 0.0559. The changes are 4.86% and 17.68%.

Though the productivity is high, the wage level is low. This might lower the morale of employees. If the low labor's share is raised, the wage level is increased. Yet this means decreasing dividends or retained earnings. Lowering the capital's share is not good for the firm in terms of long-range view. Therefore further improvement of the productivity should have high priority.

(53 CF)

The (53 CF) indicates that the productivity is not high enough, LSS are not low enough, and PCPE is not very low. The time series analysis indicates that all three measures show improvement. This could be the result of the investment, but as mentioned above, it is not satisfactory. The conclusion of EFSA backs up this evaluation.

☆☆☆ The evaluation of the productivity has been completed. Productivity is FAIR.

Here, EFSA has ended the productivity analysis with the appraisal of FAIR, which comes from the appraisal of VALP, the overall productivity measure.

#### 4-4 STABILITY ANALYSIS (STABILITY-FRAME)

☆☆☆ The analysis of stability evaluates whether the firm has sufficient solvency and funds to capture an investment opportunity. Every firm has various long and short-term liabilities, so financial stability is fundamental. Would you care to analyze the stability of the firm? [YES NO]

> YES

(Data input for the stability analysis. See Table 5.)

(Prompt for the explanation of CR for the short-term financial stability)

> YES

☆☆☆ The formula for the current ratio is  $(\text{Current assets})/(\text{Current liabilities}) \times 100$ . The current liabilities are the liabilities which the firm has to repay within a year. It is desirable that these liabilities are covered by the assets which can be cashed in within a year. The current ratio will tell you the liquidity of the firm, i.e. how much liquidable assets(current assets) the firm has, compared with the maturing obligations(current liabilities), using the industry average as a criterion.

(Prompt for the criterion of CR)

> 142.20

☆☆☆ The current ratio of the firm is BELOW the average of the industry: 124.26. The difference from the average(142.20) is -12.62%. The current ratios for the last three years are 150.51, 131.50, and 124.26. The changes are -12.63% and -5.51%.

(Prompt for the explanation of QR)

> YES

☆☆☆ The formula for the quick ratio is  $(\text{Quick assets})/(\text{Current liabilities}) \times 100$ .



The numerator for CR includes the quick assets(cash, marketable securities, and receivables), the inventories, and the other assets(prepaid expenses etc.). It is often argued that the inventories and the other assets can hardly be regarded as the liquidable assets. So the quick ratio uses only the quick assets for its numerator. This ratio therefore provides a stricter test of liquidity than CR, using the industry average as a criterion.

(Prompt for the criterion of QR)

> 88.90

☆☆☆ The quick ratio of the firm is ABOVE the average of the industry: 89.94.

The difference from the average(88.90) is 1.17%.

The quick ratios for the last three years are 104.04, 87.40, and 89.94. The changes are -15.99% and 2.91%.

(Prompt for the explanation of CAR)

> YES

☆☆☆ The formula for the cash ratio is  $(\text{Cash})/(\text{Current liabilities}) \times 100$ . The basic idea of this ratio is same as that of the quick ratio but more strict. It uses only cash for its numerator and uses the industry average as a criterion.

(Prompt for the criterion of CAR)

> 28.10

☆☆☆ The cash ratio of the firm is ABOVE the average of the industry: 28.70.

The difference from the average(28.10) is 2.14%.

The cash ratios for the last three years are 40.66, 33.46, and 28.70. The changes are -17.71% and -14.23%.

(Prompt for the explanation of NIB)

> YES

☆☆☆ The formula for the net interest burden is  $(\text{Net interest})/(\text{Sales}) \times 100$ . The net interest means (Interest and discount paid - Interest and discount received). It is often said that NIB should not exceed 3-5%. This measure will check whether the firm has too much loans payable or not, using a benchmark of 4%.

☆☆☆ The net interest burden of the firm is WITHIN the prescribed limits: 1.07.

The difference from the limit(4.00) is -73.25%.

The net interest burdens for the last three years are 5.21, 0.45, and 1.07.

The changes are -91.36% and 137.78%.

☆☆☆ CR is below the average, but the reason is that the firm has few inventories and/or other assets. My evaluation of the short-term financial stability is GOOD. (57 CF)

The quantity of loans payable has become less. The appraisal of the short-term financial stability is GOOD. However, the CF is only 57. This means that QR and CAR are not high enough (+1.17% & +2.14%). Furthermore, the time series analysis indicates that all three measures, including CR, are deteriorating. Therefore, the future of the firm is unsure.

(Prompt for the explanation of LR for the long-term financial stability)

> YES

☆☆☆ The formula for the liability ratio is  $(\text{Equity capital})/(\text{Borrowed capital}) \times 100$ . When the firm's performance becomes poor, the solvency becomes poorer, loans payable becomes larger, the firm has less equity capital compared with borrowed capital, and the financial stability becomes lower. In such a case, the ratio is low. Therefore it can be said that the smaller the ratio, the lower the long-term financial stability, using the industry average as a criterion.

☆☆☆ The liability ratio of the firm is BELOW the average of the industry: 35.32.

The difference from the average(41.60) is -15.10%.

The liability ratios for the last three years are 37.72, 39.35, and 35.32. The changes are 4.32% and -10.24%.

(Prompt for the explanation of FAR)

> YES

☆☆☆ The formula for the fixed assets ratio is  $(\text{Equity capital})/(\text{Fixed assets}) \times 100$ . The fund invested in the fixed assets will not be collected soon, so the equity capital should be regarded as the reservoir from which the long-term fund can be covered, using the industry average as a criterion.

(Prompt for the criterion of FAR)

> 58.40

☆☆☆ The fixed assets ratio of the firm is ABOVE the average of the industry: 61.69.

The difference from the average(58.40) is 5.63%.

The fixed assets ratios for the last three years are 77.78, 63.43, and 61.69.

The changes are -18.45% and -2.74%.

(Prompt for the explanation of LTFR)

> YES

☆☆☆ The formula for the long-term fund ratio is  $((\text{Equity capital}) + (\text{Fixed liabilities})) / (\text{Fixed assets}) \times 100$ . The underlying principle is same as that of FAR. Yet many Japanese companies have been taking advantage of the financial leverage and have a large number of loans payable. In such a situation, the fixed assets cannot be covered by the equity capital only. LTFR checks whether the fixed assets are covered by  $(\text{Equity capital}) + (\text{Fixed liabilities})$ , using benchmark of 100%.

☆☆☆ The long-term fund ratio of the firm is ABOVE the criterion: 126.62.

The difference from the criterion(100.00) is 26.62%.

The long-term fund ratios for the last three years are 161.73, 129.85, and 126.62. The changes are -19.71% and -2.49%.

☆☆☆ Though long-term fund can be covered by the equity capital, the firm has too much borrowed capital. My evaluation of the long-term stability is FAIR. (83 CF)

The appraisal of the long-term financial stability is FAIR. However, the CF is 83, which refers to the fact that FAR is only +5.63% above the criterion. The time series analysis indicates that all three measures are deteriorating. These facts are consistent with results of ROE and ROOA. In addition, it is inferred that the investment, which was pointed out in the productivity analysis, has been made by loans payable. The fact that the firm has held a large amount of loans payable supports the conclusion about the failure of the investment.

☆☆☆ The evaluation of the stability has been completed. The short-term stability is GOOD and the long-term stability is FAIR.

In the stability analysis, there is no overall measure like ROTA in the profitability analysis and VALP in the productivity analysis. In other words, the user cannot draw any conclusion from any single measure. So, EFSA uses its combinatorial appraisal for the evaluation of the stability.

#### 4-5 GROWTH ANALYSIS (GROWTH-FRAME)

☆☆☆ The analysis of growth evaluates whether the firm could attain growth in terms of the sales and the profit. The ultimate goal of Japanese firms is long-term survival and growth, therefore, the growth factor must be analyzed in a corporate appraisal. Would you care to analyze the growth of the firm?  
[YES NO]

> YES

(Data input for the growth analysis if necessary)

(Prompt for the explanation of SGR)

> YES

☆☆☆ The formula for the sales growth rate is (Sales of the latest year)/(Sales of the year before)\*100. This index shows an increase rate of the sales from the year before last, using the industry average as a criterion. This is the most typical and popular index for a growth rate.

☆☆☆ How much is the average sales growth rate in the industry?

Here, I will show the WHY which is one of the important functions of expert systems.

The user can ask this question anytime during the consultation to know why the expert system needs the information being prompted for.

> WHY

☆☆☆ AVE-SALES-GROWTH-RATE is needed to determine

RULE 191

If SALES-GROWTH-RATE is greater than or equal to AVE-SALES-GROWTH-RATE,  
Then it is definite that SALES-GROWTH-RATE-EVA is 2 and KEY-WORD is ABOVE.

> 119.96

☆☆☆ The sales growth rate of the firm is ABOVE the average of the industry:  
125.00.

The difference from the average(119.96) is 4.20%.

(Prompt for the explanation of TYSGR)

> YES

☆☆☆ The formula for the two years sales growth rate is ((Sales of the year before) + (Sales of the latest year))/((Sales of two years before last) + (Sales of the year before))\*100. This index shows the average increase rate of the sales from two years before last, using the industry average as a criterion. Since SGR fluctuates every year, this index should be calculated.

(Prompt for the criterion of TYSGR)

> 112.34

☆☆☆ The two years sales growth rate of the firm is ABOVE the average of the industry: 118.87.

The difference from the average(112.34) is 5.81%.

(Prompt for the explanation of OIGR)

> YES

☆☆☆ The formula for the ordinary income growth rate is (Ordinary income of the latest year)/(Ordinary income of the year before)\*100. This index shows the increase rate of the ordinary income from the year before last. If the profit does not grow, it is not a real growth even if the sales grows. It is an apparent or a pretended growth. Therefore, it is necessary to check the growth of profit for an evaluation of growth.

(Prompt for the criterion of OIGR)

> 139.61



☆☆☆ The ordinary income growth rate of the firm is BELOW the average of the industry: 109.76.

The difference from the average(139.61) is -21.38%.

☆☆☆ The sales has been growing favorably, but the growth has not contributed to the profit. In this case, there is a possibility that the firm made a large investment in plant and equipment and/or research & development. Concerning low OIGR, see the analysis of profitability. Concerning the investment in plant and equipment, check the machinery and equipment account(in the property, plant and equipment account of B/S) and the depreciation expenses account(in the expenses account of the detailed statement of manufacturing cost). Concerning the investment in R & D, check the R & D account(in the selling, general and administrative expenses account of the income statement) and the development expenses account or the experimentation & research account (in the deferred charges account of B/S). My evaluation of the growth is GOOD.  
(63 CF)

The (63 CF) indicates that the growth of sales is not very high, though two measures are above criteria. EFSA points out that the reason for low OIGR might be the result of the capital investment. This does not contradict the conclusion drawn in the profitability and productivity analyses.

Here I will show the HOW which is also one of the important functions of expert systems. The user can ask this question anytime during the consultation to know how the expert system has made a conclusion.

>> HOW

☆☆☆ EVALUATE-GROWTH

Determined to be: The sales has been growing ..... the growth is GOOD.  
by using RULE198

If 1) SALES-GROWTH-RATE-EVA is 2, and  
2) TWO-YEARS-SALES-GROWTH-RATE-EVA is 2, and  
3) ORDINARY-INCOME-GROWTH-RATE-EVA is 1,

Then 1) it is definite that KEY-WORD is GOOD, and  
2) it is definite that EVALUATE-GROWTH is

The sales has been growing ..... the growth is GOOD.

With this question, the user can know that RULE198 was used for the appraisal of the growth. In this way, the user can use HOW to verify which rule has been used for every conclusion reached, and what kind of line of reasoning EFSA has used to reach it.

☆☆☆ The evaluation of the growth has been completed. Growth is GOOD.

Finally, EFSA shows the conclusions of each goals and all of the combinatorial appraisals in the summary of the consultation.(Omission)

## 5. DISCUSSION

The appraisal of the OK company can be summarized as follows. The profitability is GOOD, the productivity is FAIR, the stabilities are GOOD(short-term) & FAIR(long-term), and the growth is GOOD. The overall profitability is high. ROE is high, although this is due to the high leverage. The performance in the main line of business is satisfactory, though the profitability of the other concomitant activity deteriorated in the third period. It is possible this was due to the loans for investment. High OIR and low RMT indicate satisfactory performance in the main line of business. Low RMT means that the firm manages its raw materials well. This keeps costs down, thus contributing to the profit. Yet OAT is not high enough due to low productivity, such as overproduction. Though the firm tried to improve productivity by investing in new equipment, the new products didn't meet user needs. They didn't sell well, and the degree of the utilization of the equipment became low. There is no urgent problem concerning the stability of the firm. However, the quantity of loans payable is large, and the future of the firm is unsure. The sales growth has reached the standard, however, the income growth has not, due to the failure of the investment.

Taken together, it has been ascertained that EFSA is capable of highly expert analyzing. Yet, there are several problems awaiting solutions. First, even if EFSA carries out the time series analysis, it does not utilize the result in its combinatorial appraisal as the author commented during the consultation. There is no problem in the cases of measures, such as COSR & SGAAER, in which the combinatorial appraisal is consistent with the time series analysis. However, great care must be taken in dealing with the cases of measures, such as LER & EP, in which the time series analysis indicates the opposite tendency. To cope with this problem, new rules for appraising the time series are indispensable.

The second problem concerns CF. CF is calculated to compensate for the simplicity of the two-level assessment in the combinatorial appraisal. Again, great care must be taken to understand and utilize the connotations of CF. CF has the advantage of enabling the expert system to represent its knowledge flexibly. Yet it has the disadvantage of making it

difficult to judge the connotations of contradictions in knowledge, or to estimate the effects of knowledge revisions.<sup>50</sup> Again, rules to improve on the simplicity of the two-level assessment are necessary.

The third problem concerns EFSA's interaction with other systems. The present EFSA is a stand-alone system. If it were connected to other systems, the data would not have to be input by the user. The user would be able to use graphics to display the relationships between the various data. These are functions I would like to add to the system.<sup>51</sup>

The final and biggest problem is that even though EFSA is an expert system for corporate appraisal, it deals only with financial data. Dealing with non-financial data and qualitative data is very important in developing future expert systems for corporate appraisal. The following are examples of rules to address that issue:

EX.1 IF   a) the strength of a firm is human rather than physical, or  
          b) the strength of a firm is soft ware based rather than hard ware based, or  
          c) the strength of a firm is net work based rather than single based, or  
          d) the strength of a firm is vitalized by responding user needs rather than stagnant,  
THEN the strength is inimitable and central to the firm's competitive advantage.<sup>52</sup>

EX.2 IF   a) a firm has know-how in a certain area, and  
          b) the economic rent expected from the development in the area is considerably attractive,  
THEN the firm would be an innovator in the area.<sup>53</sup>

EX.3 IF   a) a firm is a technology-based new enterprise, and  
          b) the degree of technology transferred from the entrepreneur's source organization into the firm is high, and  
          c) the firm does not start as a consulting and/or contract R & D firm, but as a product oriented firm,  
THEN the firm will exhibit a large scale growth and succeed.<sup>54</sup>

EX.4 IF   concerning an informal information trading  
          a) degree of competition between information providing firm and information receiving firm is low, or  
          b) availability of alternative information sources to information receiver exists, or  
          c) information's impact on domains of high competitive importance is weak, or  
          d) value of transferred information to information receiver is high, and likelihood that information receiver will reciprocate information is high, or  
          e) technical expertise of information receiver is high,  
THEN the informal information trading will occur and contribute to the profit of providing firm.<sup>55</sup>



EX.5 IF a) the CEO has knowledgeable advisors, or  
b) the CEO has high scientific thinking ability, or  
c) the CEO has high technological development ability,  
THEN PFB (preventive factors for bankruptcy) are in effect.<sup>56</sup>

EX.6 IF a) the CEO does not have entrepreneurship, or  
b) the CEO does not have leadership, or  
c) the CEO does not have marketing ability,  
THEN AFB (accelerative factors for bankruptcy) are in effect.<sup>57</sup>

These rules are developed from individual theories, and aren't organized into a consistent system. Yet it must be possible to make IF-THEN rules from the knowledge of corporate appraisal and a consistent system, because the study of corporate appraisal, which is a part of the study of management, should be, by its nature, logical and systematic. As shown in the high expertized analyzing ability of EFSA, the applicability of expert systems to corporate appraisal must be promising.

## 6. SUMMARY AND CONCLUSIONS

In recent years, research in AI, especially expert systems, has come to the notice of everyone in management. The purpose of this paper was to explore the applicability of expert systems to corporate appraisal.

One of the features of expert systems is the independence of the knowledge base from the inference engine. This feature makes it possible for the programmer to revise the knowledge independently from the total system. The facility of knowledge renewal is a very big advantage for corporate appraisal, which does not have many universally valid systems or axioms. The second feature of expert systems is that knowledge is represented in declarative module form such as IF...THEN.... Due to this feature, the domain expert can handle the system easily. The third feature is the utilization of heuristics which matches with the practical character of management and corporate appraisal. The fourth feature is the superior user interface, and the ability to accept questions WHY and HOW. Due to this feature, users can consult expert systems when making decisions, because expert systems can be thought of as ESS instead of DSS.

Utilizing these features of expert systems, I have developed an actual expert system for corporate appraisal. I have succeeded in creating an expert system capable of highly expert problem solving. Though there are several problems to be solved, the system worked well as an ESS or second opinion.

In conclusion, it is the author's opinion that the applicability of expert systems to corporate appraisal is remarkably promising.



APPENDICES

A-1 ABBRIVIATIONS OF MEASURE NAME

CAR	cash ratio	PPAET	property, plant and equipment turover
COSR	cost of sales ratio	QR	quick ratio
CR	current ratio	RMT	raw materials turnover
EP	equipment productivity	ROE	return on equity
FAR	fixed assets ratio	ROOA	return on operating assets
GT	goods turnover	ROTA	return on total assets
LER	labor equipment ratio	SGAAER	selling, general and administrative expenses ratio
LR	liability ratio	SGR	sales growth rate
LSS	labor's share	TPHP	trade payables holding periods
LTFR	long-term fund ratio	TRHP	trade receivables holding periods
NIB	net interest burden	TRT	trade receivables turnover
OAT	operating assets turnover	TYSGR	two years sales growth rate
OIGR	ordinary income growth rate	VALP	value added labor productivity
OIR	operating income ratio	VAR	value added ratio
PCPE	per capita personnel expenses	WIPT	work in process turnover

A-2 Calculation for the possible number of the kinds of corporate appraisal

Measures which are used more than twice are EP, LR, OAT, OIR, ROOA, ROTA, and VALP. When they are constant (2 or 1), the numbers of candidate for combinatorial appraisal in Table 1 are  
ROE:2, ROOA:2, OIR&OAT:1, COSR&SGAAER:4, RMT:2, WIPT:2, GT:2, TRT:2, LER&EP:2, PPAET&VAR:4, LSS&PCPE:4, SHORT-STABILITY:16, LONG-STABILITY:4, GROWTH:8. (except the case ROOA=ROTA)  
These are independent each other, so the combination is  
 $2 \times 2 \times 1 \times 4 \times \cdots \times 16 \times 4 \times 8 = 4,194,304$   
Then, there are 128 ( $2^7$ ) combinations of above seven measures for each 4,194,304,  
 $4,194,304 \times 128 = 536,870,912$   
Finally, the number of cases ROOA=ROTA is 134,217,728 which is calculated similarly, the possible number of the kind of corporate appraisal is  
 $536,870,912 + 134,217,728 = 671,088,640$  Q.E.D.

Table 1 Number of candidate for combinatorial appraisal(CA)

Goal	Subgoal*	Number of measures used in CA	Number of candidate for CA	Goal	Subgoal	Number of measures used in CA	Number of candidate for CA
	ROE	3	8		LER & EP	3	8
	ROOA	2	10		PPAET & VAR	3	8
	OIR & OAT	3	8		LSS & PCPE	3	8
	COSR & SGAAER	3	8	PRODUCTIVITY			24
	RMT	2	4		SHORT	4	16
	WIPT	2	4		LONG	3	8
	GT	2	4	STABILITY			24
	TRT	4	8				
PROFITABILITY			54	GROWTH	—	3	8
TOTAL NUMBER OF CANDIDATES				110			
POSSIBLE NUMBER OF THE KINDS OF CORPORATE APPRAISAL				671,088,640*			

(See Appendices for the abbreviations of measure name and the calculation for the possible number of the kinds of corporate appraisal)

Table 2 Common Data

COST-OF-SALES	(1352,1068,1024)	INCOME-BEFORE-TAXES	(172,160,104)
SELLING-GENERAL-AND		CURRENT-ASSETS	(840,668,596)
-ADMINISTRATIVE-EXPENSES	(376,312,252)	FIXED-ASSETS	(616,536,324)
NON-OPERATING-INCOME	(12,12,12)	DEFERRED-CHARGES	(0,0,0)
NON-OPERATING-EXPENSES	(64,36,28)	CURRENT-LIABILITIES	(676,508,396)
EXTRAORDINARY-INCOME	(0,0,0)	FIXED-LIABILITIES	(400,356,272)
EXTRAORDINARY-LOSS	(8,4,4)	AVE-NET-WORTH-RATIO	(29.38)

Table 3 Data for profitability analysis

CONSTRUCTION-IN-PROGRESS	(0,0,0)	ACCOUNTS-RECEIVABLE	(216,128,116)
INVESTMENTS-IN-SECURITIES	(8,8,8)	NOTES-RECEIVABLE	(194,134,120)
RAW-MATERIALS	(36,40,32)	ACCOUNTS-PAYABLE	(163,114,92)
WORK-IN-PROCESS	(56,52,32)	NOTES-PAYABLE	(154,132,108)
GOODS	(60,24,24)		

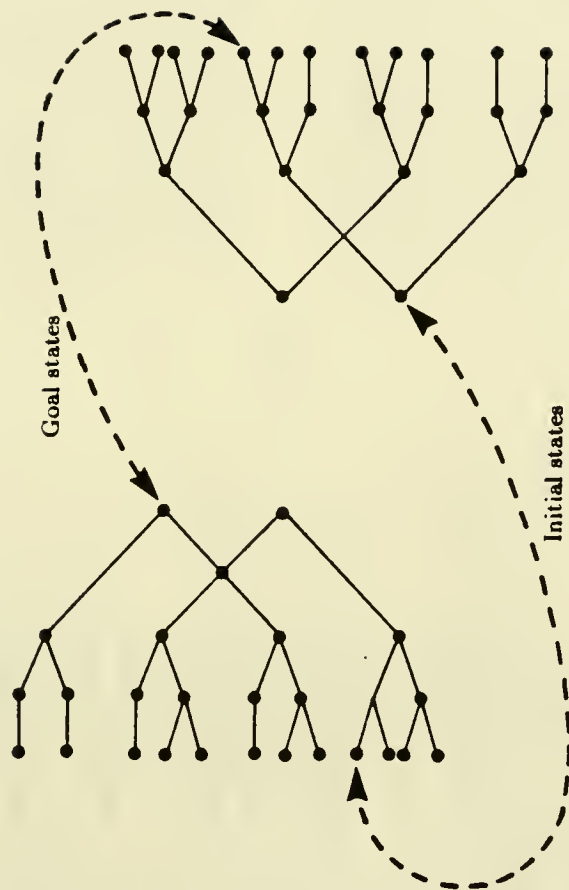
Table 4 Data for productivity analysis

VALUE-ADDED	(669,587,475)	PROPERTY-PLANT-AND-EQUIPMENT	(608,528,316)
NUMBER-OF-EMPLOYEE	(6080,5940,5780)	PERSONNEL-EXPENSES	(340,282,262)

Table 5 Data for stability analysis

OTHER-ASSETS	(80,108,96)	INTEREST-AND-DISCOUNT-PAID	(25,11,77)
CASH	(194,170,161)	INTEREST-AND-DISCOUNT-RECEIVED	(4,4,4)

Figure 1 Shape of the state space (Winston[1984] p. 152)



The shape of the state space determines whether forward chaining or backward chaining is better. Fan-in situations call for forward chaining; fan-out situations, for backward. The wrong choice can commit the problem solver to chasing too many dead ends.

# RULE006

```

SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (RETURN-ON-TOTAL-ASSETS-EVA IS KNOWN AND RETURN-ON-EQUITY-EVA
IS KNOWN AND RETURN-ON-OPERATING-ASSETS-EVA IS KNOWN AND
OPERATING-INCOME-RATIO-EVA IS KNOWN AND
OPERATING-ASSETS-TURNOVER-EVA IS KNOWN AND
COST-OF-SALES-RATIO-EVA IS KNOWN AND
SELLING-GENERAL-AND-ADMINISTRATIVE-EXPENSES-RATIO-EVA IS KNOWN
AND RAW-MATERIALS-TURNOVER-EVA IS KNOWN AND
WORK-IN-PROCESS-TURNOVER-EVA IS KNOWN AND GOODS-TURNOVER-EVA
IS KNOWN AND TRADE-RECEIVABLES-TURNOVER-EVA IS KNOWN )
THEN :: (PROFITABILITY-EVA)

```

# RULE008

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (RETURN-ON-OPERATING-ASSETS > RETURN-ON-TOTAL-ASSETS AND
RETURN-ON-OPERATING-ASSETS < AVE-RETURN-ON-OPERATING-ASSETS
AND RETURN-ON-TOTAL-ASSETS >= AVE-RETURN-ON-TOTAL-ASSETS )
THEN ::
EVALUATE-RETURN-ON-OPERATING-ASSETS = 1 AND
RETURN-ON-TOTAL-ASSETS = 1 AND
return on total assets (RoTA) is above the average level,
(RoOA) is not, but (RoOA) > (RoTA). The fact that (RoOA) is
below the average level means that the management's performance
in the main line of business is poor. The performance in the
other concomitant activity such as financial management is not
so poor because (RoTA) is above the level, however, it cannot
contribute to total profitability because (RoOA) < (RoTA).")

```

# RULE078

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (EP-MODE = FULL AND RETURN-ON-OPERATING-ASSETS-EVA = 2 AND
OPERATING-INCOME-RATIO > AVE-OPERATING-INCOME-RATIO AND
OPERATING-ASSETS-TURNOVER > AVE-OPERATING-ASSETS-TURNOVER )
THEN ::
OPERATING-ASSETS-TURNOVER-EVA = 2 AND
EVALUATE-OPERATING-INCOME-RATIO = (TEXTUAL "According to these
facts, it can be said that the reason of the high return on
operating-assets is found in the high (OAT), i.e. the firm's
policy is small profits and quick returns." )

```

# RULE090

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (OPERATING-INCOME-RATIO-EVA = 1 AND COST-OF-SALES-RATIO
AVE-COST-OF-SALES-RATIO AND
SELLING-GENERAL-AND-ADMINISTRATIVE-EXPENSES-RATIO
AVE-SELLING-GENERAL-AND-ADMINISTRATIVE-EXPENSES-RATIO )
THEN ::
(COST-OF-SALES-RATIO-EVA = 1 AND
SELLING-GENERAL-AND-ADMINISTRATIVE-EXPENSES-RATIO-EVA = 2 AND
EVALUATE-COST-OF-SALES-RATIO = (TEXTUAL "According to these
facts, it can be said that the reason of the low operating
income ratio (OIR) is found in the high (CosR). The firm can
raise its (OIR) by improving the management of (Cos). Check on
the detailed statement of manufacturing cost is recommended.")
)

```

# RULE093

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (EP-MODE = FULL AND OPERATING-ASSETS-TURNOVER-EVA = 2 AND
RAW-MATERIALS-TURNOVER AVE-RAW-MATERIALS-TURNOVER )
THEN ::
EVALUATE-RAW-MATERIALS-TURNOVER = 1 AND
management was not good and could not contribute to the high
operating assets turnover." )

```

Figure 2 Rules for profitability analysis

# RULE099

```

SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (OPERATING-ASSETS-TURNOVER-EVA = 1 AND WORK-IN-PROCESS-TURNOVER
AVE-WORK-IN-PROCESS-TURNOVER )
THEN :: (WORK-IN-PROCESS-TURNOVER-EVA = 1 AND
EVALUATE-WORK-IN-PROCESS-TURNOVER = (TEXTUAL "One of the
reasons of the low operating assets turnover should be
attributed to the low work in process turnover. This means that
the management of the work in process was poor. See the
analysis of productivity." ) )

```

# RULE103

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (OPERATING-ASSETS-TURNOVER-EVA = 1 AND GOODS-TURNOVER
AVE-GOODS-TURNOVER )
THEN :: (GOODS-TURNOVER-EVA = 1 AND EVALUATE-GOODS-TURNOVER (TEXTUAL "
One of the reasons of the low operating assets turnover) should
be attributed to the low goods turnover. The low goods turnover
means that goods had been held for a long time and that large
inventories might be kept. The goods had not been sold well
and/or had been overproduced. If there are excess inventories,
collecting invested capital tends to be slow and low turnover
of capital causes a shortage of funds, increasing the need for
loans, and increasing interest expenses. The risk of inventory
turning obsolete or deteriorating should also be considered.
See the analysis of productivity." ) )

```

# RULE111

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (OPERATING-ASSETS-TURNOVER-EVA = 1 AND
TRADE-RECEIVABLES-TURNOVER < AVE-TRADE-RECEIVABLES-TURNOVER
AND TRADE-RECEIVABLES-HOLDING-PERIODS >
TRADE-PAYABLES-HOLDING-PERIODS )
THEN :: (TRADE-RECEIVABLES-TURNOVER-EVA = 1 AND
EVALUATE-TRADE-RECEIVABLES-TURNOVER = (TEXTUAL "The trade
receivables holding periods (TRhp) is less than (or equal to)
the trade payables holding periods (TPhp) ;"
TRADE-RECEIVABLES-HOLDING-PERIODS <
TRADE-PAYABLES-HOLDING-PERIODS
TRADE-RECEIVABLES-HOLDING-PERIODS NEXT-LINE "One of the reasons of
the low operating assets turnover should be attributed to the
low (TRr). The low (TRr) means that collecting trade
receivables takes longer than the average. This can be happen
when the firm had inactive selling or could not take favorable
policy regarding the credit duration. In this case, the risks
of bad debt and low turnover of capital become larger and even
frozen credits can be exist." ) )

```

# RULE119

```

=====
SUBJECT :: PROFITABILITY-ANA-RULES
IF :: (RETURN-ON-TOTAL-ASSETS-EVA = POOR AND RETURN-ON-EQUITY
AVE-RETURN-ON-EQUITY AND LIABILITY-RATIO-EVA-S
D, )
THEN :: (RETURN-ON-EQUITY-EVA = 1 AND EVALUATE-RETURN-ON-EQUITY = (
TEXTUAL "Both the total profitability and the equity
profitability are not good. If the firm increased its borrowed
capital, equity profitability would become higher as a result
of the financial leverage effect. Yet improvement of total
profitability should have high priority." ) )

```



Figure 3 State Space of ROE

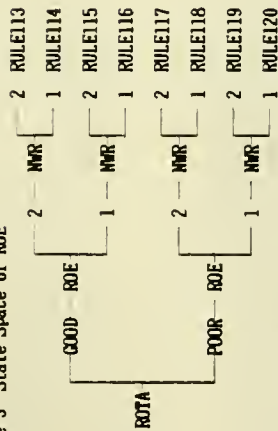


Figure 4 State Space of R00A



Figure 5 State Space of OIR &amp; OAT

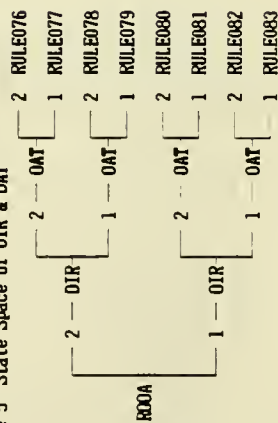


Figure 6 State Space of CCSR &amp; SCAAR

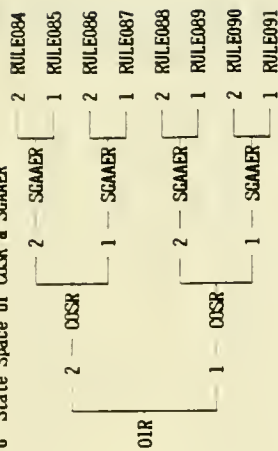


Figure 7 State Space of RMT

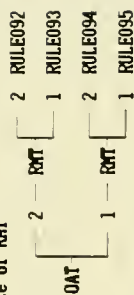


Figure 8 State Space of WPT

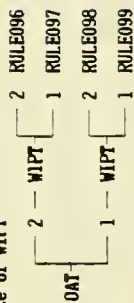


Figure 9 State Space of GT

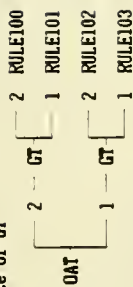
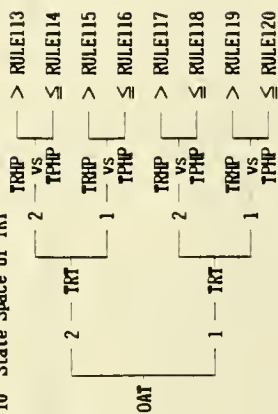


Figure 10 State Space of TRT



RULE216

```

SUBJECT :: PRODUCTIVITY-ANA-RULES
IF :: (VALUE-ADDED-LABOR-PRODUCTIVITY-EVA IS KNOWN AND
      LABOR-EQUIPMENT-RATIO-EVA IS KNOWN AND
      EQUIPMENT-PRODUCTIVITY-EVA IS KNOWN AND
      PROPERTY-PLANT-AND-EQUIPMENT-TURNOVER-EVA IS KNOWN AND
      VALUE-ADDED-RATIO-EVA IS KNOWN AND LABOR-S-SHARE-EVA IS KNOWN
      AND PER-CAPITA-PERSONNEL-EXPENSES-EVA IS KNOWN )
THEN :: (PRODUCTIVITY-EVA)

```

RULE229

```

SUBJECT :: PRODUCTIVITY-ANA-RULES
UTILITY :: 100
IF :: (EX-L-E-R IS KNOWN AND VALUE-ADDED-LABOR-PRODUCTIVITY-EVA =
      POOR AND LABOR-EQUIPMENT-RATIO >= AVE-LABOR-EQUIPMENT-RATIO
      AND EQUIPMENT-PRODUCTIVITY < AVE-EQUIPMENT-PRODUCTIVITY )
THEN :: (LABOR-EQUIPMENT-RATIO-EVA = 2 AND EQUIPMENT-PRODUCTIVITY-EVA
      = 1 AND EVALUATE-LABOR-EQUIPMENT-RATIO = (TEXTVAL "According to
      these facts, it can be said that the reason of the low
      productivity (the value added labor productivity) is found in
      the low quality of production by the equipment (the equipment
      productivity). The firm can raise its productivity by improving
      the quality of production by the equipment. The details will be
      analyzed in the next step. If the labor equipment ratio has
      been increased, there is a possibility that the firm made an
      investment in plant and equipment. Check the machinery and
      equipment account (in the property, plant and equipment account
      of R/S) and the depreciation expenses account (in the expenses
      account of the detailed statement of manufacturing cost.)" ) )

```

RULE234

```

SUBJECT :: PRODUCTIVITY-ANA-RULES
UTILITY :: 100
IF :: (FP-MODE = FULL AND EX-P-P-A-E-T IS KNOWN AND
      EQUIPMENT-PRODUCTIVITY-EVA = 2 AND
      PROPERTY-PLANT-AND-EQUIPMENT-TURNOVER >=
      AVE-PROPERTY-PLANT-AND-EQUIPMENT-TURNOVER AND
      VALUE-ADDED-RATIO < AVE-VALUE-ADDED-RATIO )
THEN :: (PROPERTY-PLANT-AND-EQUIPMENT-TURNOVER-EVA = 2 AND
      VALUE-ADDED-RATIO-EVA = 1 AND
      EVALUATE-PROPERTY-PLANT-AND-EQUIPMENT-TURNOVER (TEXTVAL "
      According to these facts, it can be said that the reason of the
      high quality of the production by the equipment (the equipment p
      roductivity) is found in the high degree of utilization of the e
      quipment (the property, plant and equipment turnover). The firm
      can raise its quality of the production by the equipment further
      by improving the quality of the equipment itself (the value add
      ed ratio). Investment in a state-of-the-art equipment is recomme
      ended for production of high value added products." ) )

```

RULE240

```

SUBJECT :: PRODUCTIVITY-ANA-RULES
UTILITY :: 100
IF :: (FP-MODE = FULL AND EX-L-S-S IS KNOWN AND LABOR-S-SHARE
      AVE-LABOR-S-SHARE AND VALUE-ADDED-LABOR-PRODUCTIVITY-EVA
      GOOD AND PER-CAPITA-PERSONNEL-EXPENSES =
      AVE-PER-CAPITA-PERSONNEL-EXPENSES )
THEN :: (LABOR-S-SHARE-EVA = 2 AND PER-CAPITA-PERSONNEL-EXPENSES-EVA
      = 1 AND EVALUATE-LABOR-S-SHARE (TEXTVAL "The productivity is
      high, the wage level is high, and the labor's share is low. I
      could not find any problems regarding distribution of value
      added." ) )

```

Figure 12 State Space of LER & EP

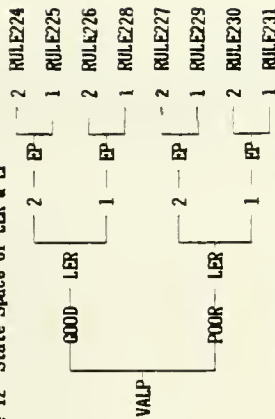


Figure 13 State Space of PPAET & VAR

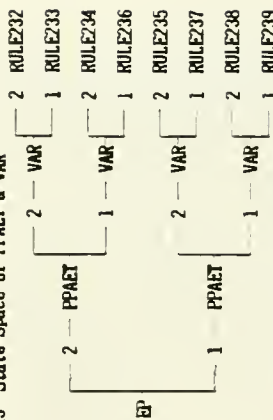


Figure 14 State Space of LSS & PCPE

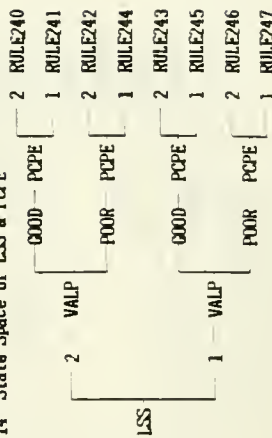


Figure 11 Rules for productivity analysis

Figure 15 Rules for stability analysis

RUI, F. 1991

SUBJECT : STABILITY-ANALYSES  
 SUBJECT : (SHORT-STABILITY IS KNOWN AND LONG-STABILITY IS KNOWN)  
 THIN : (STABILITY-EVA)

RILF 361

SUBJECT : STABILITY-RATIO-RULES  
 TITLE : CURRENT-RATIO-EVA = 2 AND QUICK-RATIO-EVA 3 AND  
 CASH-RATIO-EVA 1 AND NET-INTEREST-RATIO-EVA 1 )  
 THEN : (SHORT-STABILITY - POOR AND EVALUATE-SHORT-STABILITY (TEXTUAL  
 "The firm has a large number of loans payable and little cash  
 though the current ratio and quick ratio have desirable  
 figures. My evaluation of short-term stability is poor." ) )

RULE 43

SUBJECT : STABILITY-ANA-RULES  
 REF : (LIABILITY-RATIO-EVA - 2 AND FIXED-ASSETS-RATIO-EVA - 2) AND  
 (LONG-TERM-RATIO-EVA = 1)  
 THEN : (LONG-STABILITY = GOOD AND EVALUATE-LONG-STABILITY - (TEXTUAL "  
 The long-term fund ratio is below 100%. Yet in this industry,  
 many firms have a large quantity of fixed assets and a small  
 quantity of fixed liabilities. My evaluation of long-term  
 stability is good." ) )

Figure 16 State Space of SHORT-STABILITY

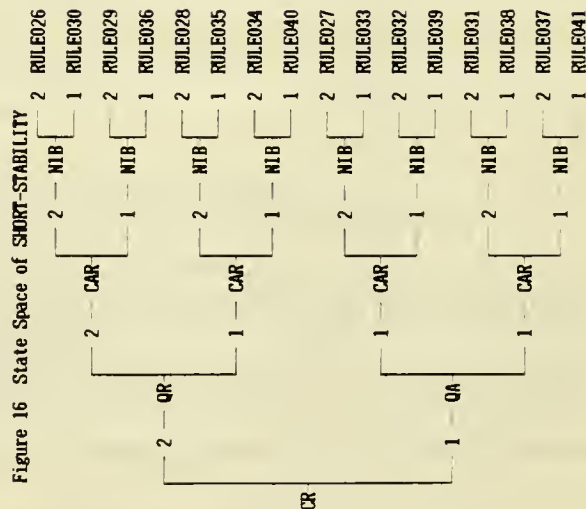


Figure 17 State Space of LONG-STABILITY

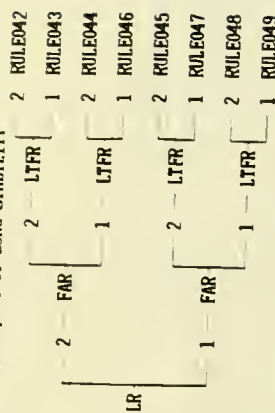
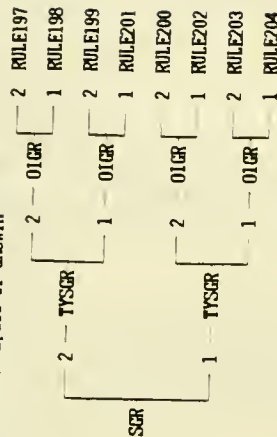


Figure 18 State Space of Growth



**Figure 19 Rule for growth analysis**

BILF. 190

SUBJECT :: GROWTH-ANA-RULES

$$\text{IF } 1: (\text{SALES-GROWTH-RATE-EVA}_1 \text{ AND TWO-YEARS-SALES-GROWTH-RATE-EVA}_2 \text{ AND ORDINARY-INCOME-GROWTH-RATE-EVA}_3 = 0)$$

THEN : (GROWTH- $\Delta$  FAIR AND EVALUATE-GROWTH = (TEXTUAL "though the growth of sales is below the average of the industry in the latest year, it has grown favorably in long-term. My evaluation of growth is FAIR, yet one noteworthy fact is that a farm cannot grow fast in terms of rate if a size of the farm is very big."))





## NOTES

- 1) Kagaku Gijutsu chou[1985] p.140.
- 2) Winston[1984] p.1.
- 3) Ueno[1989] p.9.
- 4) Kagaku Gijutsu chou[1985] p.8.
- 5) McDermott[1981] pp.21-29., Bachant[1984] pp.21-32., van de Burg[1986] pp.33-39.
- 6) Davis[1981] pp.846-849.
- 7) Dzierzanowski[1989] pp.168-172.
- 8) Feigenbaum[1988] pp.127-131, 175-178, 229-234. & Tsunozaki[1987] pp.1-10.
- 9) Ueno[1989] p.46.
- 10) Bouwman[1983] pp.653-672.
- 11) Luconi[1986] pp.3-14.
- 12) Thierauf[1990] p.188.
- 13) Elmer[1988] pp.1-29.
- 14) Messier[1988] pp.1403-1415.
- 15) For instance, see Elliott[1985], Harmon[1985], Henderson[1987], Hertz[1988], O'Keefe[1988], Silverman[1987], Vasarhelyi[1988]
- 16) Shimizu[1981] p.7.
- 17) Ueno[1989] p.20.
- 18) Shimizu[1981] p.2.
- 19) In Japan, most experts in social science do not have any degree in natural science.
- 20) IF-THEN rule is the most popular type of knowledge representation technique in expert systems. Such expert systems are called rule-based expert systems. For the rest, there are frames and semantic nets for knowledge representation. See Waterman[1985] pp.63-79.
- 21) Waterman[1985] p.154.
- 22) Kagaku Gijutsu chou[1985] p.10.
- 23) Shimizu[1984] p.1.
- 24) Not all expert systems have this ability.
- 25) Davis[1977] p.34.
- 26) Kelly[1986] p.379.
- 27) Luconi[1986] pp.3-14.
- 28) Okamoto, K. [1984], [forthcoming]
- 29) See 3-4.
- 30) Frame is a PC-PLUS term which refers to a group of rules and parameters. Actually EFSA has five frames which include a root frame for the common data input.
- 31) Okamoto, K. [1984] p.75. Also see the analysis of ROTA in 4-2.
- 32) Waterman[1985] p.66.
- 33) Winston[1984] p.182.
- 34) Attendant processes such as printing are also executed by rules and those rules work with the forward chaining.
- 35) See 3-4.
- 36) About the definitions and the explanations of measures, see chapter 4. All decisions about financial statement analysis used in this sector will also be explained to the user during the consultation, see chapter 4. For abbreviations of the measures, see A-1.
- 37) See chapter 4.
- 38) For the combinatorial appraisal which will be mentioned later, the two-level assessment is used, i.e. GOOD(greater than or equal to the criterion) or POOR(less than the criterion).
- 39) Waterman[1985] p.16.
- 40) A sign of inequality can be reversible.
- 41) See A-2.
- 42) Ueno[1989] p.57.
- 43) Cases which occur only by a mathematical chance may be included.
- 44) User can use any unit for input as long as it is constant during the consultation. Here, I use 100 million yen (\$770,000).
- 45) If NO is selected, EFSA will skip the profitability analysis.
- 46) If NO is selected, EFSA will skip the explanation. Though YES will be selected for every prompt for explanations hereafter, readers those who are versed in or not interested in financial statement analysis may skip the explanations.
- 47) As this is the function common to explanations of all measures, it will be omitted hereafter. Though HOW function of PC-PLUS is used for convenience' sake, see 4-5 for the original usage of HOW.
- 48) As this is the function common to all combinatorial appraisals, it will be omitted hereafter.
- 49) See 3-4.
- 50) Ueno[1989] p.50.
- 51) Solutions of these three problems won't be difficult, however, EFSA has not had those rules or functions because of the slow processing speed. It is difficult for a personal computer to meet those needs.
- 52) Shimizu[1990] pp.35-82.
- 53) von Hippel[1988] pp.43-55.
- 54) Roberts[forthcoming] pp.328-333.
- 55) Schrader[1990] pp.6-11.
- 56) Okamoto[1988] p.15.
- 57) Okamoto[1988] p.16.

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